Emerging Industry-University Trends, Challenges, and Interventions for Latin America

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Abstract— **Ever since the dawn of the last decade, Latin America has witnessed both an existing, entrenched, consensus on the need for changing the role of universities, as well as the incremental demand for knowledgeable-high-tech skilled labor in emerging industries. Such a role has arrived in addition to the standard roles of advanced education and research, to one more where extension, engagement, and entrepreneurship contributes to regional economic development. Hence, these institutions are compelled to increase, develop, and raise their potential in terms of training qualified, "knowledge workers" thus creating imminent direct innovation and scientific capacity building.**

Since from a technological standpoint, sustainability and abundance will never occur in a profit system, for it simply goes against the very nature of its structure, designed to maintain and promote innovative scarcity, this dyadic relationship of industry university relations must seek new alternative resources, where the end result is a competitive indigenous technology that supports a resource-based economy. To accomplish it requires access to technological and financial resources, diverse capabilities, and markets. However, since rarely are all these available in one place or embodied in one person or organization, the role of networks in disseminating information and ideas and allowing access to such resources, has, consequently, become of critical importance. So much so, it could be argued, that the viability of network connections has become a critical determinant of economic competitiveness.

In developing regions, the sphere of competencies is likely to be supplementary from the knowledge frontier, and as a result the collection of considered options is narrow. Both in developed and developing countries, industries have only inadequate knowledge of relevant technological options, and research demonstrates that they generally look for new solutions around their existing competencies (Fagerberg and Godinho 2005).

In order to steer clear of being encapsulated on a second-rate development path, technologically lagging countries are in particular need of institutional strengthening that enhances access to cutting-edge technologies, supply needed skills and strengthen local innovation networks. For the most part, Latin American universities are well positioned to meet this challenge to the extent they are at the knowledge frontier and may be trained to be responsive to the needs of firms, but compose a major portion of all national innovation systems acting as primary employers of researchers, and receiving the bulk of public subsidies for research.

There is an unprecedented potential for putting this research capacity to uses never before witnessed by their industrial counterparts, who remain suspicious of their academic counterparts. Technology-based industries could benefit prominently from the university education and research interaction. Specifically, the disparity between the long-term horizon of institution, infrastructure, and capacity building, and the short term and quickly shifting challenges of new technological paradigms, does provide the perfect setting.

This paper considers trends, challenges, and a possible intervention for Latin American universities and their relations with industry, as well as policy options available for fostering their contributions to overall development.

Keywords-Industry-University, Latin America

I. INTRODUCTION

There is fundamental consensus on the need for changing the role of universities in Latin America, as well as the incremental demand for high-tech skilled labor in emerging industries. This role comes in addition to the traditional functions of universities as institutions of advanced education and research, to one where extension, engagement, and entrepreneurship contributes to regional economic development. All these institutions are compelled to increase, develop, and raise their potential in terms of training qualified 'knowledge workers', thus creating insights of direct relevance to society, and engaging in commercial activity.

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Innovation is complex socio-economic phenomenon that requires access to technological and financial resources, diverse capabilities, and markets. Rarely are all these available in one place or embodied in one person or organisation. Indeed, most non-routine innovations appear to occur around the intersection of fields and functions. The role of networks in disseminating information and ideas and allowing access to resources, capabilities, and markets has, thus, become of critical importance. So much so, it could be argued, that the viability of network connections has become an important determinant of economic competitiveness.

In developing regions, the sphere of competencies is likely to be complementary from the knowledge frontier, and as a result the collection of considered options is narrow. Both in developed and developing countries, industries have only inadequate knowledge of relevant technological options, and research demonstrates that they generally look for new solutions around their existing competencies [1]. Moreover, the possibility of introducing new products and processes depends on research and development (R&D) capabilities and skills that are often non-existent. In order to steer clear of being encapsulated on a second-rate development path, technologically lagging countries are in particular need of institutional strengthening that enhances access to cutting-edge technologies, supply needed skills and strengthen local innovation networks. For the most part, Latin American universities are well positioned to meet this challenge to the extent they are at the knowledge frontier and may be trained to be responsive to the needs of firms, but compose a major portion of all national innovation systems acting as primary employers of researchers, and receiving the bulk of public subsidies for research. Indeed, in countries like Argentina, Mexico, Brazil, and, Colombia universities employ more than 70 percent of all researchers.

There is an unprecedented potential for putting this research capacity to uses never before witnessed by their industrial counterparts, who remain suspicious of their academic counterparts. Technology-based industries could benefit prominently from the university education and research interaction. Specifically, the disparity between the long-term horizon of institution, infrastructure, and capacity building, and the short term and quickly shifting challenges of new technological paradigms, does provide the perfect setting [2].

This paper considers trends, challenges, and a possible intervention for Latin American universities and their relations with industry, as well as policy options available for fostering their contributions to overall development. Particularly, it proposes that academia can assist in, training such organizations to perceive how innovation relies on knowledge – and the development of capacity to build, absorb and utilize knowledge (See Figure 1).

Additionally, it reviews several articles related to the Triple Helix Model and also reviews several major studies from the World Bank, ECLAC, UNESCO, and the IADB. While is not aimed to provide an in-depth analysis, it does focus on some of the central issues suffered by universities in Latin America like their definition of knowledge transfer as merely commercialization of research and licensing. It also proposes a revised role of universities in all aspects of academic practice including advanced applied research, their contribution to national innovation systems, production of advanced human capital and its relation to industrial needs, and, the manner in which commercial activity places a challenge on university governance structures and management. Finally, three key areas are explored: a) access to institutions and infrastructure for innovation, b) ownership and appropriability of knowledge and innovation, and, c) usability and transferability of capabilities.

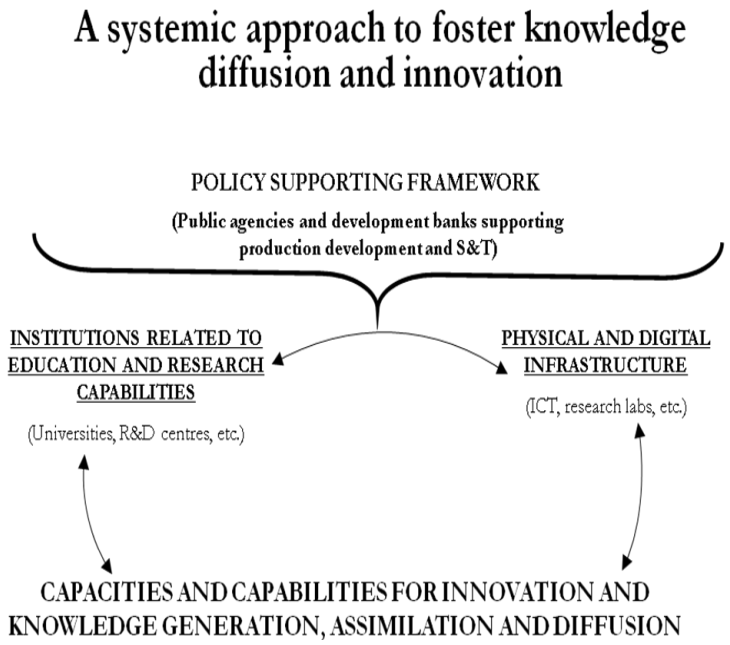

Figure 1: A Systemic Approach. (Source: ECLAC 2004)

II. A New Mission

The newest mission of the university as an institution taking over a role as actor of economic development, politics, and, knowledge deliberation with society as a whole, has been the focus of study by Etzkowitz [3] and others interested in the potential for the interrelationship between academia, government and industry – the so-called 'triple-helix' concept. This theme proposes that interplay between governments, industry, and universities should be institutionalized and fostered. For some authors contributing to the growing literature on this subject a econocentric approach is adopted which perceives sees the role of the university to stimulate the economy. Its goal is to optimize the transfer of research results to industry, so they can transform them into innovative products and services, leading to economic growth and wealth creation. The government assists this transference through funding, and facilitating political and legal conditions. Etzkowitz [3] portrays this approach as a development from the linear knowledge flow model, where knowledge and human capital are transmitted through publications and certified workers, to a spiral model where industry gives feedback and interacts in the knowledge production and refinement. For Latin America, though, the struggle has been with really decentralizing public funding beyond capital city universities, and whereas national universities seem to understand the positive correlation, regional do not.

The triple helix approach advocates the "capitalization of knowledge." Specifically, in universities this "has occurred in three stages: securing of intellectual property; restructuring of research groups to generate a large intellectual property base; and, establishing of corporate vehicles – spin-off firms – within universities to maximize the return on intellectual property." Etzkowitz has envisioned the entrepreneurial university undergoing a second revolution, the first was when they took on research, and the emergence of a 'new academic institution,' "one that is oriented much more directly to playing a role in behalf of the state as an agency of economic development." He further contends that "Traditionally, the most deeply held value of scientists is the extension of knowledge. To contribute to this is the highest striving of a scientist. The incorporation of 'extension of knowledge' into a compatible relationship with 'capitalization of knowledge' is a profound normative change in science."

As part of this Etzkowitz describes the incubation process, viewed as a matrix, with "some slots more or less filled and various gaps left open in different countries and regions". He explains how incubator firms in most countries typically face the problem of lack of access to seed venture capital on reasonable terms. For the purposes of this paper, the author illustrates the case of the FINEP, the Brazilian national development agency, and how it recently launched INNOVA, a program to create funds to fill such gap, while Israel provided a grant of funds upon admission to its incubator program. Furthermore, It explains how in Denmark, there is a fund to invest in incubator firms, but poses the problem of lack of market representation abroad. Accordingly, an incubator at the National Technological University in Norway has addressed this issue by stationing a representative at an incubator in Palo Alto. In this Hemisphere, organizing incubators can be systematized by formalizing the Brazilian experience, in

which an older incubator facility at a large university serves as an informal hub, "*mentoring and benchmarking for newer incubators at smaller universities."* Finally, and as a prelude to the proposal of the emergence of the entrepreneurial university, Etzkowitz addresses the model incubator or 'incubator of incubators' that could be established as the central node of a network of incubators and as a training facility for future incubator directors. He mentions the way the concept brings together the training students in Mexican incubators with the networking of incubators in Brazil, "into an entity explicitly designed as an educational facility to train incubator directors and firm founders in firm-formation and networking".

Etzkowitz also suggest that in the Latin America's case, the 'incubator of incubators' concept for a model training facility and linkage node is also useful to begin the incubation process in a region or country, such as Honduras. Such a facility could send out trained people from the 'mother' or hub incubator to staff 'daughter' incubators. For example, from an initial site in San Pedro Sula, incubators could be replicated in other cities and towns in Honduras as part of a network to promote technology transfer and diffusion of new business models. His final example of how this happens is the Polytechnico Milan, and how it recently adopted such model, "to link incubators at its satellite campuses in the Lombardy region to the main campus in Milan.*"* But, whichever the case may be, it is necessary to assess the reality of Latin American SMEs to witness how, in turn, they also face complex challenges.

III. THE INDUSTRY CHALLENGE

How can small and medium enterprises (SMEs) grasp the dynamic of innovation from specific technology and innovation policy initiatives? Dr. Nicholas Vonortas [4] would suggest that the economics of industry, when they rely on industrial statistics have little meaning for innovation and learning. Learning, because of its roots in local firms, needs to be seen through a microscope of specific studies, not though the lenses of macro-statistical analysis. He argues technological learning, either internally or through technology transfers is basically a process that is influenced by the idiosyncratic nature of the firms. Depending on the nationality, type of company, the type of market, the type of technology, a different process can be achieved, even in a same industry. Take for instance, a Latin American sector outlined throughout his work, which touches countries such as Mexico, Chile, Panama (City of Knowledge) and Brazil: textiles. In this sector there are large firms, SMEs, firms linked to foreign investment, and companies living on their own market. Successful companies are not necessarily all located in electronics or telecommunications, even if the more dynamic nature of the technological sectors is proving to be more "technology-pushing" than textiles. In Risaralda, in the south of Colombia, the city of Pereira has been actively promoting textile and clothing industries. In Panama City, a technology centre has been set-up that promotes up-grading of technology in processes, in marketing, in stock-management, in logistics, in informatization, in CAD design [5]. The "Innovation Centre" of Texpinal in south central Colombia, has a record of three successful years of technology promotion that has been oriented towards more than 100 local SMEs in textiles. They are becoming dangerous to, say Morocco or Mexican firms, not so much because of low costs of the workers but also because of a strong management practice centred on technology.

Chemical products are another good example. In Mexico, Vonortas reviews some 130 firms in textile through a survey and in-depth interviews. He concludes there are companies successful in technological learning which have a longer and more sustainable growth. They are not the most financially efficient firms, however, are ones that stay longer on the market. Apparently, firms' external linkages are of paramount importance, and should be cared for by policy-making. Linking industries to technology providers is always a difficult task and strategic alliances are rare in developing countries. In Latin America, the message apparently has gone through, since a large variety of experiences now exist that promote cooperation agreements, local promotion of innovation, the creation of industrial clusters and so on. The comparison of Malaysia and Brazil (Manaus) is also interesting since it shows that policy does have an impact on the creation of industrial clusters, mainly because firms are responsive to measures that make their economic environment more profitable. This also helps a methodological conclusion in that there is need of an army of researchers going into the firms, technology canters, and technology transfer units in universities to understand the specific situation in each location.

Additionally, policy implications from his work conclude how manufacturing has created a major inconsistency: "while we fancy talking about the advent of the "post-industrial" era, we often tend to be carried away by parochial manufacturing models in policy making. It has always been known that service sectors account for a large share in our economies; we have now started to understand that they also play an extremely important role in technological innovation [4, pp. 32–36]." It is, in fact, recent developments in ICTs that have helped both make the role of services in innovation much more prominent than ever before and enhance the tradability of service sector products. Although some of the policy implications above also apply to service sector SMEs, it is certain that services are much different than manufacturing to deserve special attention.

Most importantly for the purposes of this paper though, is how SME focus should not be taken to imply a disregard of a very important set of agents of technological and organizational change: large firms and their relationship with universities. SME proponents occasionally come across arguing as if SMEs matter just because they are small and flexible, and as if they can survive in a world of their own. Reality is, in fact, more complicated. More often than not, the SMEs that attract attention tend to be the

successful ones, those that have managed to grow quickly from a direct relationship with a neighboring superior academic institution. And, Vonortas argues "quite frequently, SMEs that aspire to be central players, instead of market niche operators, succeed by aligning with larger, sophisticated, demanding customers in long-term relationships. Business analyses have shown that the secret of success for many SMEs has often been their relationship with a few large, sophisticated customers that provided the necessary focus and market discipline and helped the entrepreneurs to "ride" the market" [4, pp. 37]. All of which, received help from some kind of industry university collaborative R&D.

IV. Regional Academic Challenges

Increasing access to international higher education and research systems for talented Latin American students, irrespective of their background or country of origin, is at the heart of strengthening knowledge and innovation in their countries. An estimated 1.5 million students worldwide currently study abroad. Roughly half of them come from countries in the Organization for Economic Co-operation and Development (OECD), and more than 40 percent from East and South Asia. Only a few students from Africa, the Middle East, and Latin America get the opportunity to mix with their peers in other countries.

This World Bank Study [6] overviews developments in higher education in Latin America, in order to assess the region's inclination to acknowledge the potential of the knowledge economy and the globalization of higher education. Considerable progress has been made in recent years. Enrollment in higher education has risen to almost one-third of the 18–24 age cohort, and growth of private provision and non-university tertiary education have expanded learning opportunities. Quality assurance mechanisms are being established in the region, and institutions are increasingly being held accountable for their performance. Latin American countries offer many possibilities for students wishing to enroll in advanced education, and recent advancements hold considerable promise for bringing the region closer to the international knowledge frontier.

Important progress notwithstanding, talent is underused due to considerable inequities. Widespread inefficiencies reduce the return on the use of scarce resources, the lack of credit transfer mechanisms impedes national and international mobility, and the region falls far short of building a critical mass of researchers of international repute. The process of internationalization has important implications for Latin America, especially with regard to gaining access to the rapidly increasing pool of knowledge and know-how. The internationalization of education appears not yet to have reached a sufficient level of importance on the political agenda. A large number of Latin American students study outside Latin America, and many university graduates emigrate to the north. Latin American countries have not been able to develop adequate strategies to attract foreign students or skilled nationals from abroad. It is therefore likely that Latin America in general will not reap the full benefits of the General Agreement on Trade in Services (GATS).

The study further suggests increments on productivity and innovation, by opening their economies thru liberalizing trade and encouraging foreign investment. Integration into the world market has improved the region's access to technology and amplified the importance of knowledge as a factor of production. Productivity and competitiveness gains associated with the use of new technologies have increased the demand for advanced human capital. As a result, the relative wages of workers with higher education are on the rise everywhere in Latin America. In Brazil, for example, returns to higher education rose 23 percent between 1982 and 1998, while returns to primary and secondary education decreased (Figure 2). The payoffs to higher education are high in most Latin American countries. The rate of return is twice as high as the return to secondary education in Argentina, Chile, and Colombia and more than five percentage points higher in Brazil, Bolivia, and Mexico. A striking feature of Latin America is the fact that the rise in relative wages has taken place in parallel with increases in the relative supply of workers with higher education. Observed wage changes may therefore not fully reflect the increase in demand for higher education graduates.

However, innovation remains a supporting actor as the driver of economic growth, since access to advanced human capital is yet to become both crucial in the productive sector, and a central component of national innovation systems. Data shows the lack of ability for public institutions and private firms to interact in a concerted way to generate and adopt knowledge, technology, and products as a primary driver of economic growth. Countries in Latin America have unrealized potential for improving their innovative capacity. The number of scientific publications and patents is low, and ties between universities and the private sector are weak, and while there is still low investment and private sector involvement in research and development (R&D), it almost doubled in Latin America between 1990 and 2001. Increases in spending were particularly large only in Mexico, Chile, and notably Brazil, which has traditionally given high priority to research at federal universities. The region still falls considerably behind world leaders in the field. In 2010, Latin American countries as a whole allocated only 0.64 percent of GDP to R&D, while the average for the OECD was 2.54 percent. Ireland allocated 1.54 percent and the Republic of Korea 2.70 percent of GDP to R&D. Large structural differences exist between Latin America and the OECD with regard to the financing and execution of research. In OECD countries private industry is the main investor in R&D. In Latin America, by contrast, the bulk of research is financed by the government and carried out by public research institutes and universities. In Chile, for example, industry accounts for only 15 percent of research; in Peru the figure is just 10 [8]. Research activities at private universities are also very limited in Latin America because of a focus on instruction and the low availability of qualified researchers among the faculty. In addition,

the high percentage of part-time faculty places private institutions in a weak position to carry out research. Complementing public resources by encouraging private sector investment in R&D would provide Latin America with a much stronger basis for research and commercialization of innovations. Now, it is not commonly safe to use R&D as the proxy for innovation (and link it to productivity) because of our limited knowledge on how to measure such activity - stuff that goes on outside of R&D labs and in the service sectors, for example, because other innovative activity is just as important. Nevertheless, when R&D spends is used as a proxy, it still probably works okay as a comparator between countries, rather than as an absolute. The danger is when the policy solutions that come from R&D analysis is again similarly channeled directly at finding an R&D solution.

V. Initial Interventions

But how then can a region begin seriously transform itself into an innovation hub, given that all conditions seem to be in the right place, and timing has never been better. Etzkowitz and Klofsten [9] provide some interesting answers to this fundamental question. They suggest that: "The key event is the creation of an entrepreneurial university, whether from an existing academic base or a new foundation, which takes initiatives together with government and industry to create a support structure for firm formation and regional growth… result of these initiatives is a self-sustaining dynamic in which the role of academia and government appears to recede as industrial actors come to the fore and a lineage of firms is created….. as one technological paradigm is exhausted and another one is needed as the base for new economic activity, the role of academia and government comes to the fore again in creating the conditions for the next wave of innovation." Table 1 depicts their stage model framework by which this might take place.

TABLE 1.
KNOWLEDGE BASED REGIONAL DEVELOPMENT – A STAGE MODEL. SOURCE: ETZKOWITZ AND KLOFSTEN [9].

Stage	Goal	Structure	Process	Activities
Incipient stage: Idea about new regional development model.	Generate a new economic base for the region.	Informal interaction between different actors as university, municipality, research labs, large and small firms.	Searching for success - informal meetings, discussion about regional plans, influence of external ideas and successful cases.	Building the first incubator; initial service activities for early firms in incubators, basic infrastructure.
Implementation stage: Starting new activities.	Supply adequate infrastructure (hard and soft) for different types of entrepreneurs.	Formation of networks of entrepreneurs, Informal educational and social activities	Starting new organizations for promoting entrepreneurship.	Spin-off-firm-club SMIL, networks, incubators and Science parks, initiatives outside and inside of the university.
Consolidation and adjustment stage: Integration of hard and soft activities.	Increase the efficiency of the system.	Co-operation among regional actors for the purpose of increased efficiency of resources; to get closer to firm needs in order to satisfy needs of firms.	A new networking plan and network of support organizations.	Meetings between actors to define the roles and to support each other in marketing.

The basic argumentation here, is that at the heart of the 'triple helix' model of innovation for Latin America, there must be a network of collaboration between firms, subcontractors, universities, research institutions and government institutions aimed at generating useful knowledge and enhancing prospects for the development of innovation capability. The 'triple helix' system places emphasis on inter-organizational linkages, and the structures of the public and private sector organizations, which provide the context within which innovation thrives. Networks and other forms of collaboration can assist in dealing with growing uncertainties and complexities resulting from transition to market economy, globalization of markets, and rapidly changing technologies.

Accordingly, Etzkowitz and Klofsten advocate knowledge-based regional development by proposing implementation and follow-up of four clear-cut, specific stages (Table 1). The heart of the process is the networking of institutional spheres, which can ensure the attainment of effective and rapid learning through proximity and collaboration between the main actors or institutional spheres. The 'triple helix' system is thus akin to acknowledging the significance of local/regional systems of innovation, and the relationship between innovation and specific locations. The main objective of the proximity and close collaboration between the three main spheres - state institutions, universities and industry - is to produce, share and disseminate knowledge, thus locating the university at the centre of the 'triple helix' model of innovation and scientific and technological capability development.

The ‘triple helix’ system thus represents a radical departure from the conventional transfer of technology and knowledge. It requires new intra- and inter-organizational arrangements and culture, all of which require considerable commitment and resources and take time to develop [10]. The merit of the system is that it is capable of creating the conditions for generating, sharing and disseminating appropriate knowledge conducive to quick learning and innovation necessary for speedy catching up and growth. Moreover, the system thrives in the breakdown of the monopoly culture of rent-seeking vested interests, and in the liquidation of the political culture of centralization of power underlying the state of institutional fragmentation observed in developing countries.

The close and informal relationships that can develop in a ‘triple helix’ model can facilitate the transfer of both explicit and tacit knowledge which is important in developing countries [11]. Tacit knowledge, however important, is difficult to interpret, articulate, formalize and communicate. It can only be transferred, shared and transferred through close collaboration [12]. Morgan and Hunt (1994) [13] link close and informal relationships with mutual trust, commitment and high quality and frequent communications. This type of communications is more likely to facilitate the exchange of detailed information between organizations. Thus, a fundamental feature of the ‘triple helix’ model is its aim to bring together different actors, capitalizing on their interactions in order to provide a comprehensive understanding of the innovation process and its key determinants. It views innovation as a product of a complex and non-linear set of activities involving interactions within and between the principal players. It can be seen as deriving from a combination of both continuous and discontinuous innovation based upon previous learning and experiences but also requiring a significant level of ‘unlearning’ and new ‘way of doing things’ – what Schumpeter refers to as “creative destruction.”

The innovation process assumes that each helix or organizational sphere experiences a high level of interactions and goes through a complex process of transformation. Effectively coordinating and managing all interactions, interfaces and transformations happening within industry-university relations in Latin America calls for the ability to create, manage and reshape relationships between individuals and organizations. It requires new intra- and inter-organizational arrangements and culture, all of which require considerable commitment and resources and take time to develop.

VI. Latin American Relations to Low-Tech Firms

Additionally, understanding how learning and knowledge can occur, and the development of the policies necessary to facilitate and support innovative activities, is reliant on understanding and categorizing industrial sectors. As is illustrated in the Oxford Handbook of Innovation [14], technology firms occupy a central position in modern economies, and drive economic growth, productivity gains and have created new industries and innovative products and processes. Also, their importance is reflected in the wide coverage they receive in the mass media and in the business literature. Many even believe that these “technology firms” constitute a different breed of firms that differ in important aspects from others. So, why study them here, and why are they important to the Latin American context, especially those considered “Low-Tech?”

While there is a consensus that these firms emphasize technological activities and technology-based innovations, there is a lack of agreement in the literature about the specific criteria to be used in deciding which firms should be included in this category and in classifying firms according to their technology level. Some observers even characterize this situation as “definitional Tower of Babel” [15].

Lacking clear guidance, some researchers simply use a firm’s industry membership as the defining criterion (e.g., computers versus food). Others use as the classification criteria one or a number of characteristics assumed to be associated with these firms. Often, the characteristics used are ad-hoc reflecting the specific, and often narrow, perspective of the researcher. Failure to agree on criteria hampers research advancements, and negatively affects policy and investment decisions, which when converting Industry-University relations in Latin America and the Caribean (LAC) becomes a major obstacle for approaching this analysis.

Accordingly so, Von Tunzelmann and Acha [14], drawn from the lack of agreement, explore why technology firms scholars and researchers formulate their own idiosyncratic criteria and classifications, and seeking safe and common ground, opt to study only firms from the industries popularly considered as “high technology” (e.g., computers,bio-technology) avoiding the study of firms from other industries such as food and textile. Popularly viewed as low technology, these industries in fact include firms displaying substantial levels of technological activity, bias which has been recently recognized and raised as an important research subject.

For the authors, this lack of agreement limits researchers’ ability to systematically compare the findings of empirical studies, and forces them to arrive at generalizations regarding technology firms’ behavior and performance. They further suggest the financial community and venture capitalists often pursue investment strategies targeting technology firms in general or in specific

sectors. The design and implementation of these strategies could benefit for similar reasons from the existence of criteria based on findings derived from systematic research, which can be used in the selection and classification of these firms. They insist that attempts to characterize and classify technology firms should recognize the complexity of the technology phenomenon and its ubiquity. Researchers' basic understanding of the notion of a "technology firm" is likely to vary depending on their discipline, the issues researched, and the intended audiences. This, however, is not a reason for dismissing the need for reaching agreement regarding criteria and working definitions. Rather, the above means that a number of perspectives are possible and researchers focusing on criteria and classifications should specify their own perspective and the situations where it is relevant.

For the purposes of this paper and the way policy making should be tackled in LAC, they find that technology firms differ from others in their positioning on three dimensions: R&D activity and the organizational elements and market conditions associated with it, corporate culture, and product strategy. These dimensions capture the essence of the technology firm as seen by specific groups of researchers desiring to connect with industry in the region. Furthermore, these three dimensions can be used to determine not only the technology level of specific firms but also their technology profile. In fact, the use of the same criteria to classify firms is likely to advance research. It enables meaningful comparisons among empirical studies and opens up the possibility of studying research questions requiring comparisons among firms positioned at different technology levels or characterized by different technology profiles [16].

Similarly, it now becomes possible to systematically study differences in the structure, behavior, culture, and strategies among technology firms from different industries and economies. Also, Latin American researchers can identify and characterize different types of technology firms, and develop systematic typologies based on these firms' position on the three dimensions. In turn, this opens the way for the study of technology firms' evolution and change, and of the factors influencing and shaping these developments. For instance, study of the existence of "low technology" firms in an industry commonly considered as "high technology" (electronics), and of "high technology" ones in industries commonly considered as "low technology" (food, textile). While for macro types of policy and investment decisions, industries, rather than firms, may still be the relevant unit of analysis, for purposes of direct support and other micro decisions, firms, not industries, may be the more appropriate unit. This is also true for studies assessing the impact of these policy decisions (see also Morgan and Sayer, 1988). [17]. Finally, to the extent the motivation for classification is driven by different perspectives regarding technology and technology firms, the approach suggested in this article could be easily adapted to represent the particular perspective by generating the set of criteria most relevant and appropriate in particular situations, which would be highly beneficial for the Latin American region and its emerging IU trends.

VII. Corresponding Policy Implications

Accordingly so, since Latin American contexts have a tendency to tie innovative developments with tow-tech industries, and the their public institutions have pervaded those pre-driven-results, this relationship needs to be readdressed from an expert perception, and as such it is once again Etzkowitz [18] who delineates a model that takes account of overlapping and co-development among technological and institutional transformation, along with a regional research project, in order to reveal processes of innovation outside a single organization, lateral relationships across boundaries, and hierarchical bureaucratic structures. These developments and their future, he concludes, need a new model of the relationship between the institutional spheres and their internal transformation. He further assesses, "…having traditionally existed apart from each other, with academia as part of the governmental sphere, the triple helix is sometimes taken as a normative model. Some view it as a goal to strive for in bringing about change to enhance the prospects for innovation. Other observers see the coming of the triple helix as representing the replacement of the existing system of innovation, represented by government owned corporations sponsoring laboratories adjacent to university campuses (p. 22)."

As a 1990s Latin American economic tendency, imposed by the Washington Consensus, the systematic privatization of companies reduced the resources available for R&D, including collaborations between the state-owned companies' laboratories and university researchers. On the other hand, many of these collaborations were not sufficiently market driven, and resulted in innovations that lacked a context to be put to use, having been based upon a negotiation between two public laboratories, neither of which was closely enough tied to production and use [19].

Interestingly enough, and perhaps even opportunistic, this gap is not only a peculiarity of Latin American public research, but has been noted in large US corporate laboratories, that had been separated from production facilities and were operating as isolated entities, until quite recently. The article illustrates how in the later case, the reintegration of the laboratory into the firm and directing it more closely toward company goals has been occurring at IBM and GM, in recent years. Typically as corporate

R&D facilities are moved closer to product development, longer term R&D is conducted in collaboration with other firms, university research groups and government laboratories[1].

Also relevant to this paper, one can also look at this overlapping of institutional spheres as involving knowledge, consensus and innovation spaces, created at the intersection of the spheres. There is no necessary order to this sequence. A reversal of traditional orders of staged development is among the possible outcomes. Anyone can be the basis for the development of the others but a fully developed triple helix will eventually comprise all three elements. These spaces are created as a consequence of a change in values among promoters of regional economic development from a sole focus on "business climate" and subsidies to firms to creating the conditions for knowledge-based economic development. One indicator of this shift is the increased involvement of universities and other knowledge producing and disseminating institutions, such as Academies of Science, in regional development. The first step in a three-stage process of knowledge-based economic development is the creation of "knowledge spaces" or concentrations of related R&D activities in a local area. The existence of such "reticulated" agglomerations has been identified as a precursor to knowledge-based regional economic development (Casas, Gortari and Santos, 2000). [20]

Notably, we have the Knowledge Space, concept developed by Dr. Rosalba Casas [21] at Universidad Nacional Autonoma de Mexico, as a way of conceptualizing some of the decentralization of research institutes from Mexico City to other regions of Mexico, it provided a base for the development of research projects and new technology related businesses in areas of the society which had not previously had this potential. Second, is the Consensus Space that asks the question: how are knowledge spaces transformed from potential to actual sources of economic and social development? Thru a venue that brings together persons from different organizational backgrounds and perspectives for the purpose of generating new strategies and ideas. The concept of knowledge-based regional economic development is derived from activities of the New England Council, representing academic, business and political leaders. Based on the formation of firms from research at MIT in the 1920's, MIT President Karl Compton proposed to utilize the region's comparative advantage, its extensive academic base, to systematically create new firms from scientific research [22](Etzkowitz, 2004). Third, the author outlines the Innovation Space, as a new organizational mechanism that attempts to realize the goals articulated in the consensus space. From the analysis of the resources in a region and the creation of a consensus space bringing the different actors in a society together, a new innovation space is created, and, in this instance the venture capital firm provides business advice, technical assistance and financing to start new firms. Within specific regional contexts, like for instance the Colombian case, which will be addressed in the next section, universities, governments and industry are learning to encourage economic redeployment through the development of loosely coupled reciprocal relationships and joint undertakings. A sound and robust argument for the Latin American context is that for this to happen, a local region must have some scientific and technological institutions, and have produced or obtained access to other necessary kinds of innovation supporting instruments, such as investment mechanisms and institutions to promote concerted action, which is specifically reviewed for the Colombian case below.

VIII. THE COLOMBIAN CASE [23]

When Colombian economic growth began declining following liberalization in the early 1990s – just as it had in Finland at that time – the exact opposite policy as that of Finland was adopted . Instead of increasing public funds for science and technology, opting to invest and develop their way out of the crisis, Colombia's commitment to and funding of R&D declined. The Finnish case more than anything shows that determined investment in science and technology can spur high economic growth. By the late 1990s, the UK too had recognized the need the necessity of public investments in the innovation system, and put an end to a deteriorating trend in R&D expenditures.

Today's age represented by a global knowledge economy, funding of science and technology is of paramount importance in pursuing economic growth and development. In fact, without substantial S&T funding, other S&T efforts are likely to have little impact. Thus, when Colombia developed a national innovation system in the 1990s in accordance with a number of key trends in most developed countries, these good developments did not have the desired strong effects. The focus of science and technology policy shifted from science to innovation, from intervention to institutional facilitation, and from targeting large companies to targeting SMEs and cluster development – but actual, overall innovation and economic growth performance did not improve. As one of this study's interviewee remarked, "It matters little how good the seed is, if it is not watered [23, pp. 94]."

The study does help outline one positive aspect of the recent history of science and technology policies in Colombia in the 1990s, which is that, given the efforts to create a good institutional structure, considerable economic growth can indeed be achieved in the future, if substantial funds for S&T are supplied and utilized in a strategic manner, which of course, is what the

[1] However at the same time big companies are also experimenting with 'open innovation'.

Finnish case shows. A recent World Bank study argued that the main explanation of Colombia's weak innovation performance is "the lack of collaboration between the private sector and research organizations such as universities." From this perspective, improving relations between the university and industry is of paramount importance. Three cultural barriers to such collaboration exist, however. Developing and implementing a broad strategy for increasing *trust*, *self-confidence* and *understanding* in the Colombian innovation system could potentially have a substantial impact on Colombia's innovation and economic growth performance. Trust across the university and business sectors of the economy; national self-confidence in the S&T potential of the Colombian economy and its people, and understanding of the concept and necessity of S&T investment.

Making the education of private sector CEO's and other high-level managers a core element of this strategy is likely to have a particularly strong impact, given that the reluctance of private sector managers to invest in S&T and to interact with university researchers, is a key constraining factor in the Colombian NIS. Indeed, educational programs for professionals from both the business and the university sector, teaching them how to benefit from each other, could be a promising way of promoting collaboration and innovation across these two sectors. Another core element of such a strategy should be increased funding schemes for collaborative research. There are few mechanisms more effective than this in stimulating trust and development of more positive attitudes across the university and business sectors.

Another key problem in the Colombian innovation system, which may be said to be of a cultural nature, is the strong prioritization of teaching over research and third mission activities. Two important absences in the legal framework of the Colombian innovation system must be stressed in relation to this: first, the absence of a national guideline for recruitment and promotion at universities, emphasizing engagement in R&D activities with the productive sector, and second, a permanent, separate stream of funding for university engagement in R&D activities with the productive sector. Previously, one reasoning on this issue was that the time university professors expend in collaborative R&D projects was the investment that universities should rightly make, paralleling the investments made by COLCIENCIAS and the involved R&D enterprise, respectively. There is increasing recognition, however, that this line of reasoning is insufficient to stimulating collaborative research, simply because in most universities there are no funds free to be invested in this manner. [24]

An example illustrates this previous point. For many years, shrimp farms in the northern region of Colombia had showed no interest in doing cooperative research with university researchers in the field. However, when shrimp firms in 1995 were hit by disease, a cooperative research agreement was made and a project funded by COLCIENCIAS launched (CENIACUA). Not only did the project manage to cure the disease and in that sense rescue this industry. Through the cooperative research, knowledge and technologies were developed that made CENIACUA an internationally recognized key source of knowledge in shrimp disease combating, with foreign delegations visiting regularly. The CENIACUA case serves to illustrate that when cultural barriers – such as lacking trust between university and industry sectors and lacking confidence in the country's capacity for technology development – are overcome, Colombia's high potential for internationally competitive innovation and technology development comes through very clearly.

Building regional innovation systems requires a lot more than merely creating regional development agencies, or regional Technology Development Centers. At present, the vast majority of research projects financed by COLCIENCIAS are highly concentrated around the three or four largest cities of the country, in the central part of the country. This is unfortunate, for building regional innovation systems is what creates a strong national innovation system. To do so require the formulation of regional economic development strategies, backed by public funding, and it requires engaging universities and the productive sector in the formulation and implementation of these. This is an extremely important area for third mission funding. With respect to all of these fundamental problems, the university may potentially be the key change agent in the Colombian National Innovation System. This could, however, require that the need for an institutional restructuring of universities is recognized. Recent trends in funding of universities in Colombia go in the direction of performance-based funding. The logic of performance-funding is the following: 'if you perform better, you get more funding for the next term'. Though shifting funding in that direction is definitively a good and needed policy, it should not stand alone – because here too the incentive problem is not the only problem. Implicit in making a shift towards performance-based funding is the assumption that the most important constraining factor for improved performance in universities is *incentive* to perform. This is, however, often not the only constraining factor. In Colombia, most universities are financially and institutionally poorly equipped to meet the triple objective of high quality research, teaching and interaction with local industry. This is a serious constraining factor. Before universities can perform, they must be provided with funds to *transform*. Only if basic investments in university restructuring are made, will performance-based funding reach its full impact.

IX. The Interventions

Nikos Varsakelis [25] posits the following hypothesis: *The higher the quality of education is the more productive the innovative activity.* It empirically tested the role of education on the cross-country variation of innovation productivity using a sample of 29 countries for which data on the quality of education were available. The analysis departed from the quality of education, and the output of the education production. It indirectly related new knowledge to political institutions, while directly testing the impact of the quality of political institutions on innovative activity. The findings supported the hypothesis set in the theoretical part of the paper, that the higher the quality of education, the higher the output of the innovation activity. Also, the development level of the governmental efficiency was positively related to innovation activity.

For the purposes of future research for Latin American University Industry relations, the theoretical framework set up was most helpful and orienting, by explaining the relationship between economic growth and technological development, which has been rigorously established in the literature, where an increasing number of researchers has given emphasis on the determinants of technological development of the last decades. It further added that "*the main determinants that have been recognized are first, inputs in the knowledge production function such as R&D expenditures and scientists employed and second, institutional factors that are mainly proposed by the national innovation system theory, such as the level of development, intellectual property rights framework, national work-related culture, and cluster specific innovation capacity* [26] (pp. 905, Furman et al., 2002)"

Though education has long been recognized as significant in improving innovation activity, and the national innovation system literature emphasizes its significance as institutional factor, little emphasis has been given to the empirical testing of human resources development as determinant of innovation productivity. Article findings suggested how until only recently, Furman et al. [26] include in their empirical analysis public expenditures for higher education as proxy for education. They find that there is a positive relation between education resources and new patents. However, and this is a fundamental conclusion for future consideration, this author finds that education affects innovation productivity in four ways. First, scientists employed are considered as input in the knowledge production function. Scientists on the other hand are output of the education production function. Therefore, a qualitative education system with science orientation, will lead to a larger and improved pool of scientists. Second, a highly skilled workforce is an asset relatively fixed within the borders of a country. The education and training system is responsible for the creation of this highly skilled workforce pool. Third, within their research, and according to Lundvall et al. [27], the subsystem of human resources development includes the formal education and training, the labor market dynamics, and the organization of knowledge creation, and learning within firms and networks. In the concept of organization of knowledge creation and learning within firms, entrepreneurship is *conditio sine qua non*. Education helps to create a national pool of entrepreneurs who demand innovation, new products, and more efficient production methods, to gain competitiveness. Fourth, innovation networks include also customers. Michael Porter emphasizes the role of demand conditions as key driver for international competitiveness. The more sophisticated local customers are, the higher the probability local industries to develop international competitiveness. Innovation is stimulated by the presence of sophisticated quality-sensitive local customer base [26] (Furman et al., 2002). Education improves the cognitive abilities of consumers making them more demanding for qualitative products and services. This is seen as crucial as in that it suggests that "the improvement of governmental institutions efficiency and the adoption of a qualitative science oriented educational system may increase the innovative productivity of a country leading to improved growth prospects."

X. The Centrim Model

University/industry interactions have considerably evolved since the early *supply-push* models, in which users where assumed to simply lack knowledge about how best to innovate and universities were expected to provide engineering or scientific solutions, etc. Problems with this model are now well known: it is linear — universities generate knowledge *for* their partners. The model ignores the fact that firms and other organizations generate and use their own knowledge and skills. Despite these problems, the linear supply push model is still embraced by some Universities; for example though undertaking audits of science and engineering departments – as if there were treasure troves of potentially income generating ideas lying around waiting to be used. For many universities this model was super ceded by one that recognizes the knowledge base of firms and other organizations. They focus on two-way interactions between universities and users, so that both can reflect on — and improve — each other's knowledge and knowledge generation processes. This model is more a *supply-push/demand-pull* model. More recently, however, a third generation models of engagement has appeared in which universities engage with users to develop the research agenda, and to frame the outputs in a friendly and usable way: in what is often called the co-production of knowledge, often of a more applied nature. This is not (or should not) been seen as replacement for blue sky or curiosity driven research – a risk as more and more evaluations of university research attempt to assess the 'impact' of research - but a supplement to it.

However, there has also been an expectation – for some time now – that the role of a university should be broader than the traditional teaching and research agenda that we are all familiar with. Although the UK's current financial crisis has certainly

exacerbated the issue, for some time now universities have been expected to make a further contribution to the economic and social life of a region or nation through a variety of activities that are seen to make a direct impact. In so doing the interaction or, as it is now often called, the engagement of universities with public and private sector organizations has broadened from a primarily technical and scientific interaction to include a broader range of social science and humanities interchanges.

The challenge of innovation is clear and much broader than an R&D centric approach to innovation would encompass – if businesses fail to change what they offer or the ways in which they create and deliver those offerings (product and process innovation) they risk being outpaced in an increasingly competitive global environment. Innovation is important – but the key issue is not in the innovation itself but rather the *capability* within the organization to repeat the trick, to produce a continuing stream of innovation in a dynamic and shifting environment. And this is an area in which universities – due to their expertise in learning – should be ideally suited to interact with industry – in deepening and developing that capability and the capacity to generate, absorb, and utilize knowledge. It is an area that the Centre for Research in Innovation Management (CENTRIM) at the University of Brighton has focused on throughout the twenty-five years of its existence. Through their own research and that of many others, they now have a growing understanding of the elements that make up such 'innovation capability'. From a comparatively early stage in the 40 year history of the discipline of innovation studies, interest grew in looking at innovation not simply in terms of its nature (i.e. radical or incremental) or the sources (i.e. knowledge push or demand pull) but rather, *how the process was organized and managed.* Studies of learning behavior suggests that a firm's learning repertoire – its ability to construct learning experiences (by doing, by experimenting (R&D), by collaborating, etc.) leads to the accumulation of capability which placed the firm in a stronger position for future innovative activity.

One of the most influential recent contributions has been under the label of 'absorptive capacity' - how capable is a firm of acquiring and using knowledge to create new products, processes, services and thus to grow? Originally this definition was coined by [28] Cohen and Levinthal (1990) who described it as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends." [28] (Cohen and Levinthal 1990). Other authors, notably Zahra and George [29] reviewed and extended the absorptive capacity construct, suggesting that several different processes were involved – rather than a simple absorption of new knowledge there were discrete activities linked to search, acquisition, assimilation and exploitation. What they termed *'potential absorptive capacity'* relates to how a firm may value and acquire knowledge, although not necessarily exploit it. The firm's ability to transform and exploit the knowledge is captured by what they termed *'realized absorptive capacity'*. By distinguishing between potential and realized absorptive capacity they highlight the point that some firms may be aware of and even able to access new external knowledge but are unable to leverage and exploit it. Realized absorptive capacity is about accumulated learning and embedding of capabilities – search, acquire, assimilate, etc. – in the form of routines (structures, processes, policies and procedures) that allow them to repeat the innovation trick. For CENTRIM the concept of absorptive capacity represents another label or at least a large part of what we include in the idea of 'innovation capability' and can help extend our understanding of what organizational and managerial skills are needed to sustain innovation. Importantly this is not simply an analytical construct – it might also offer insights that can be used to guide policy interventions to help support firms in the innovation process. In order to make use of the absorptive capacity construct - before it can effectively be used either within policy or best practice within firms, there was the need to explore ways in which it could be dimensionalized and measured. Within the innovation studies literature there is a long-established strand of work concerned with identifying what firms need to learn to establish effective routines for search, selection and implementation. These have been used to develop various kinds of diagnostic instruments – innovation audits for example – to enable firms to assess their current capability and facilitate organizational development.

Various frameworks have been developed which cover particular aspects of innovation management, such as continuous improvement, product development and software development. Much of this work has close parallels with the themes of absorptive capacity and implicit in them are movements through different stages or levels, For example Bell's competency levels model involves a framework in which organizations pass from the point of "acquiring and assimilating imported technologies", through phases of "technology deepening and upgrading' and 'closing in on the international technological frontier' to reach a stage where the organization is 'generating core advances at international frontiers". This describes a process of moving from low or zero capability, developing minimal capability up to a level of competence, ultimately to become (high) performers. In similar fashion Arnold and Thuriaux described four degrees of a firm's levels of knowledge relating to technological capability by which a firm is eventually able to develop significantly new variants or innovations.

One of the 'products' developed by CENTRIM as part of its engagement with industry and government was an audit tool (developed with support from the World Bank) which links knowledge about key abilities in technological innovation to states of development of technological capability that enable a firm to choose and use technology to create strategic competitive advantage [30]. Innovation capabilities or absorptive capacity is clearly not evenly distributed across a population. For different reasons firms may find difficulties in growing through acquiring and using new knowledge. Some may simply be unaware of the need to

change and also lack the capability to manage such change. These enterprises differ from those that recognize in some strategic way the need to change, to acquire and use new knowledge but lack the capability to target their search or to assimilate and make effective use of new knowledge once identified. Others may be clear what they need but lack capability in finding and acquiring it. And still others may have well-developed routines for dealing with all of these issues (See [31], [32] on how this audit tool has been further developed).

Reviewing the literature on why and when firms take in external knowledge suggests that this is not a function of firm size or age. It appears instead that the process is more one of transitions via crisis – turning points. Some firms do not make the transition, others learn up to a limited level [33]. This suggests that developing innovation capacity requires a second order learning process, one geared around building capability through successful navigation of these crisis points. As firms develop maturity they become capable of managing an increasingly sophisticated set of external challenges. Arguably external intervention of some kind might help the development of capability, particularly at lower levels, and it is here that policy agents may play a role. But we also need to look more closely at the dimensions of absorptive capacity and at how it can be measured and the results used to focus development attention by policy agents – including universities [34]. This perspective should not simply tell us which firms have more or less capability but which aspects of absorptive capacity are poorly developed – e.g. search? acquire? assimilate? deploy? – and thus where to focus organizational learning. The question is *how* they might make such interventions to effect such acceleration of firm-level learning towards higher levels of absorptive capacity?

XI. CONCLUSIONS

This paper attempted to generally outline several fundamental challenges confronted by Latin American universities, their relations with industry, and their link to a National Innovation System. It is now safe to assert that further promotion of a regional perspective is absolutely and fundamentally necessary in three key areas: a) access to institutions and infrastructure for innovation, b) ownership and appropriability of knowledge and innovation, and, c) usability and transferability of capabilities. However, there are prerequisites for the successful implementation of this model, which this paper has shown to be absent for the most part throughout Latin America.

First, the conditions for the development of learning societies, which needs to be based on knowledge creation, knowledge s haring and transfer, have to be created. This assumes a central role assigned to universities that would need to improve their profiles, credibility and competence. Second, more power would need to be devoted to the main actors involved in the development of science and technology in order to facilitate the emergence of a bottom-up innovation system suggested by the 'triple helix' model. Third, stable, lasting and trusting relationships between the main actors and institutional spheres (universities, government and industry) would need to be developed. This should be supported by the development of a culture of partnerships and collaboration, and the elimination of the rigid boundaries between organizations and institutions. This calls for a comprehensive program of capacity building in developing countries, and hence for the active role of the state, not in the traditional 'top-down' sense that reinforced the fragmentation of institutional spheres, but rather in the sense of the national innovation system (NIS) that identifies the strategic players (U-I-G in the 'triple helix' variant of the NIS) and establishes a network of interactive link between them.

In Colombia's case, two policy options for providing funds for university restructuring may be distinguished. One option would be to establish a competitive fund for higher education supporting institutional improvement projects. The other option would be to tie investments in university restructuring to performance contracts made with each individual university. This policy option has the advantage of making it possible to connect such funding with other key objectives and challenges in S&T policy-making. More specifically, performance contracts with incorporated funding for university restructuring could come with the requirement that universities map the needs and potentials of their regional economies and develop strategies for how they will contribute towards developing this potential in cooperation with other actors in the regional innovation system.

Overall, universities in Latin America are well positioned to become full-fledged partners in national innovation systems and contribute to economic development. From being largely institutions of advanced education and basic research, universities are increasingly expected to contribute directly to commercial activity and economic development. The so-called "third mission" of universities is a relatively new phenomenon in Latin America, but is expected to evolve in scope and complexity as countries in the region face the challenge of developing into knowledge-based economies. Due to the novelty, visibility, and explicit impact, university-industry research partnerships and university spin-off companies have received considerable attention by policy makers and university managers. The two traditional missions of universities – advanced education and research – are, however, equally important to national innovation systems and are under similar pressure to adapt to new realities. Highly skilled individuals are the backbone of the knowledge economy and education is a key element in efforts to boost economic growth. The challenge in Latin America is to ensure that higher education is inclusive, of high quality and well aligned with the needs of the private sector and

that young researchers find employment outside academia. In regard to research, academic excellence underlies both university-industry collaboration and high-quality education. If universities are not able to deliver quality research there will be no demand for their services from the private sector. Nonetheless, university research can never be a substitute for research activities in industry and – as a matter of high priority – efforts should be made in Latin America to boost the capacity of firms to absorb knowledge. Policies on university industry linkages can add to this objective, i.e. by stimulating mobility of advanced human capital, providing services and encouraging research partnerships. Helping universities develop their "third mission" could unleash a significant innovative capacity in Latin America. This paper has pointed to a number of instruments that are used to stimulate cross-sectoral linkages, and the commercialization of university research. In undergraduate and, notably, graduate education students can be encouraged to practice in real life circumstances and work on projects in collaboration with industry. The impact of university research could be increased by converting pioneering technology into intellectual property. Moreover, countries in Latin America have unrealized potential for using public research funding to stimulate cross-sectoral research collaboration and commercialization. In a challenging global environment universities in Latin America should not expect to find "silver bullet" solutions.

Whatever approach adopted, it is indispensable that institutions monitor results and adjust instruments based on lessons learned. One of the most important challenges for policy-makers and university managers is defining a legal framework, sound management procedures and incentive systems that stimulate entrepreneurship while recognizing the distinct but complementary roles of universities and industry. It will undoubtedly require high powered incentives for cross-sectoral research, commercialization, and mobility to transform deep-rooted academic cultures in Latin America and demonstrate to the private sector that gains in productivity, value added and market shares can be achieved by collaborating with universities. Finally, it should be stressed that funding for institutional restructuring of universities may potentially be a key element in a strategy seeking to overcome one of the most severe barriers to innovation in Colombia: the lack of trust that the private sector has in universities in general, and in the potential benefits of cooperating with them in particular. Only if universities are given resources to make such institutional reforms that will enable them to streamline and professionalize their interactions with industry is the skepticism and mistrust of the private sector likely to be overcome.

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